The Charge Management System on LISA Pathfinder: Current Status and developments for LISA

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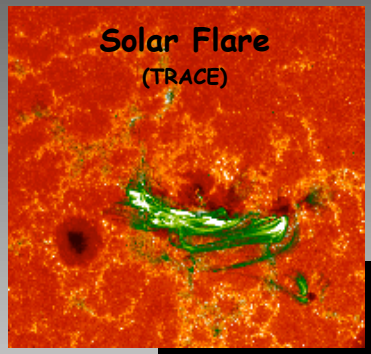
6th LISA Symposium, 19-23 July 2006 Goddard Space Flight Centre

Structure

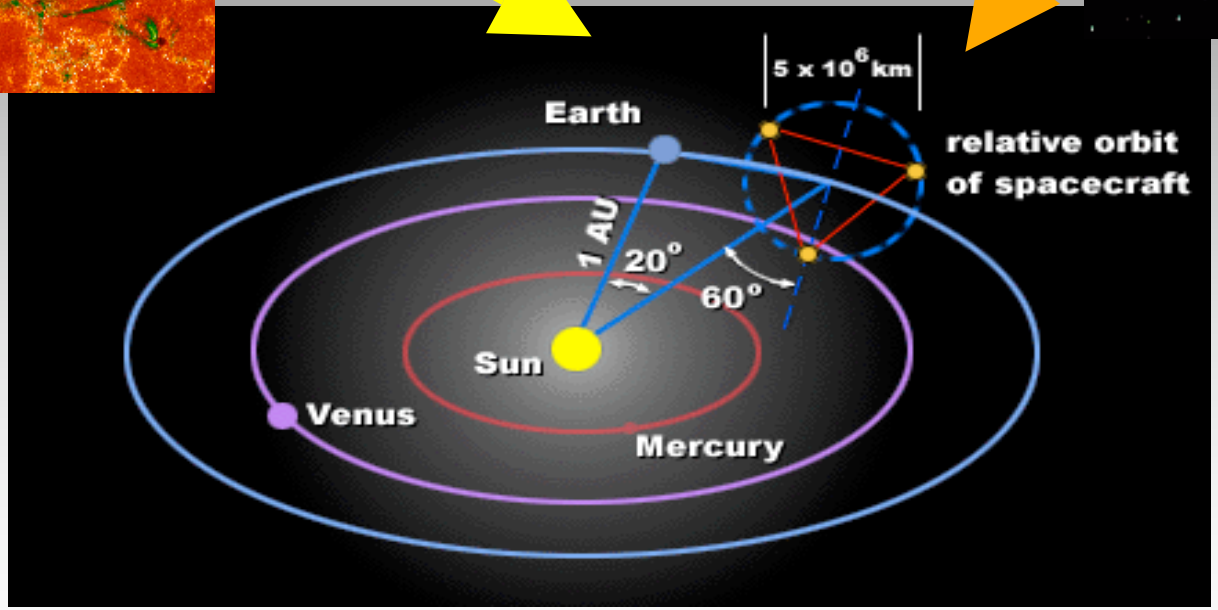
- **Introduction**
- Geant4 Simulation & Verification
- Inertial Sensor UV Kit
- UV Lamp Unit
- On Ground Testing at Trento
- Developments for LISA

Test Masses Charge Up in Space

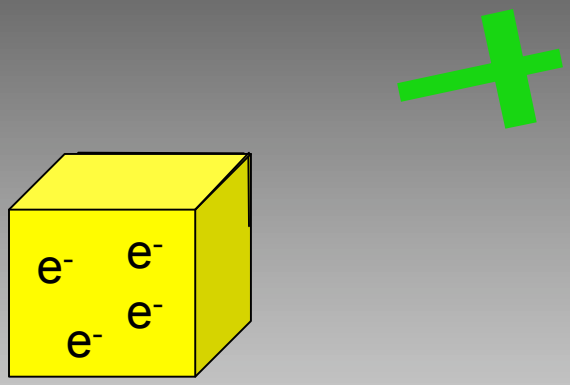


Solar particles

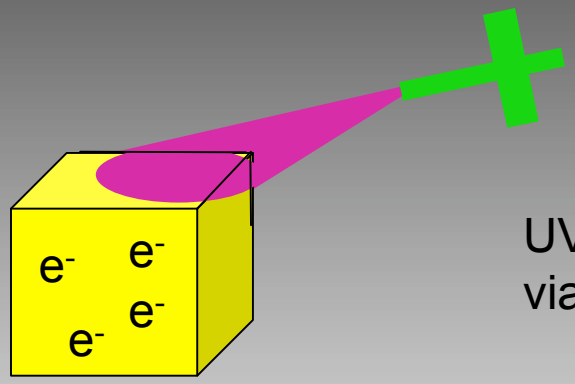
Galactic cosmic rays



Charge management

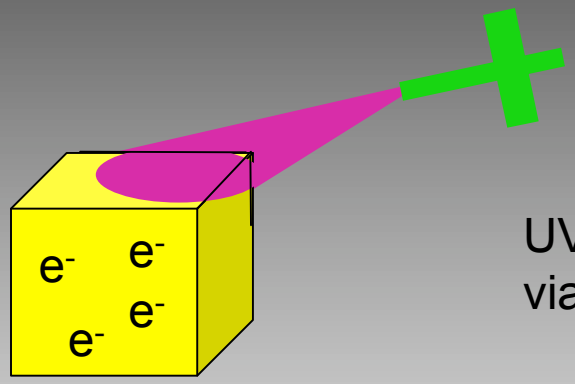


Charge management



UV light at 254 nm liberates electrons via photoelectric effect

Charge management



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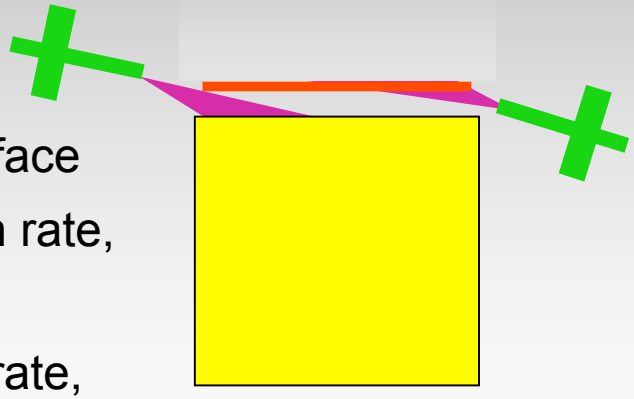

Charge could accumulate on either surface

Discharge either once every while (high rate, bias possible) or

Discharge continuously (low, matched rate, no bias)

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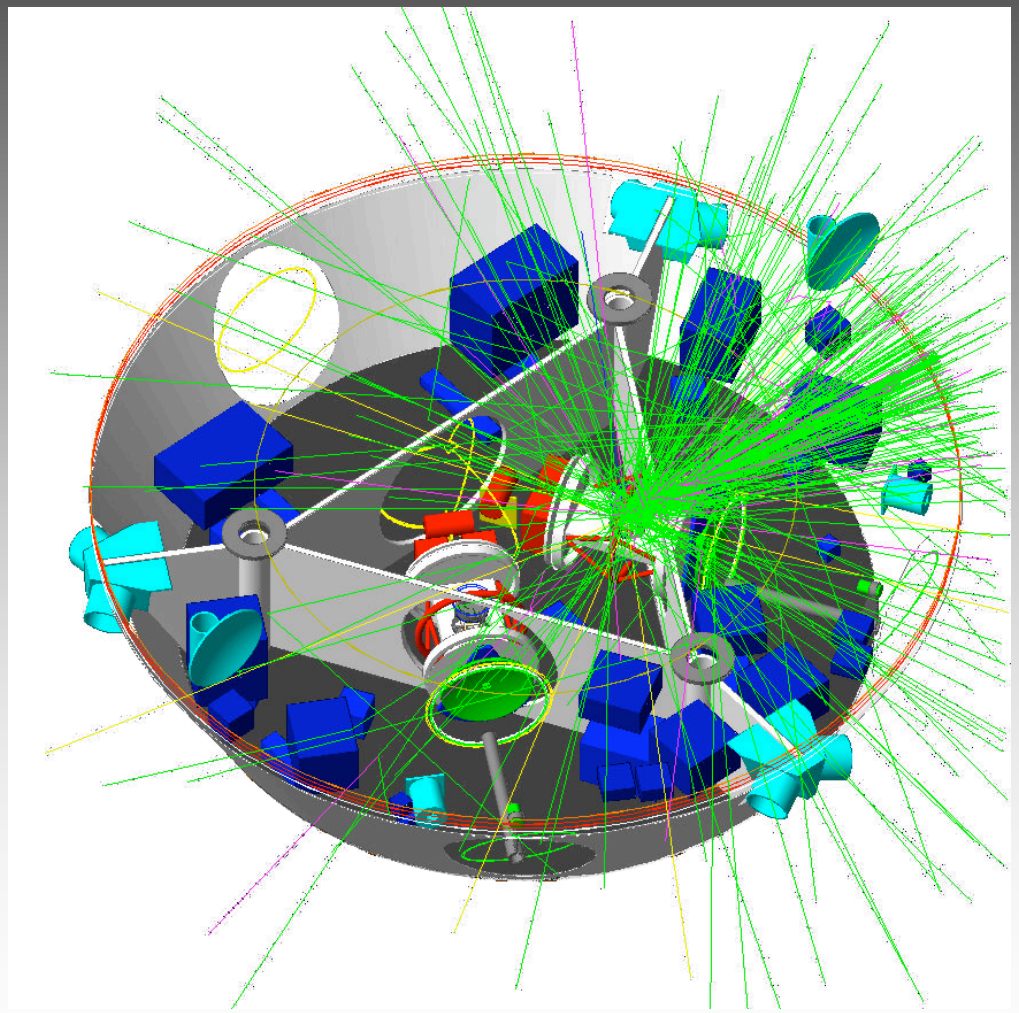
GEANT model of LISA



Araujo et al. 2005, Astropart. Phys.

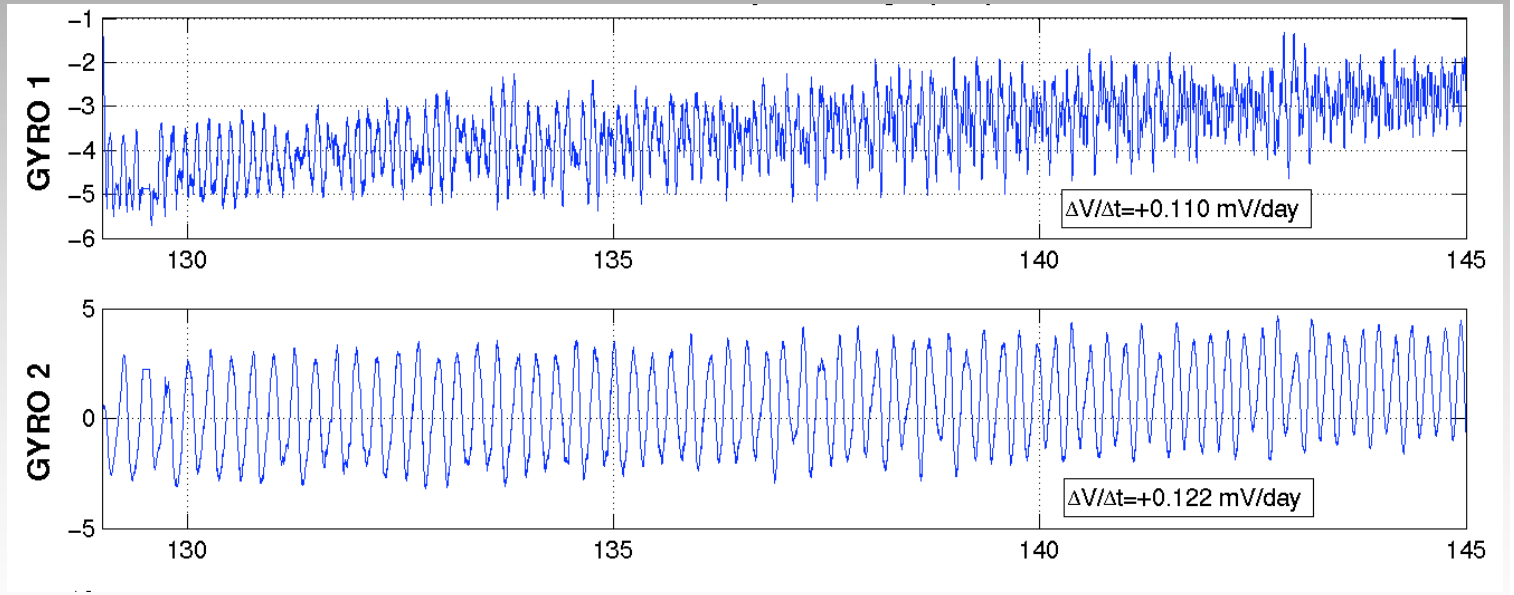
Solar minimum

R~50 +e/s

S_R=24.2 +e/s/$Hz^{1/2}$

Verifying predictions: GP-B

- Aims to detect geodetic and frame-dragging effects on free-falling gyroscopes in low earth orbit - 600km 90° inclination
- Gyroscopes accumulate charge mainly from SAA



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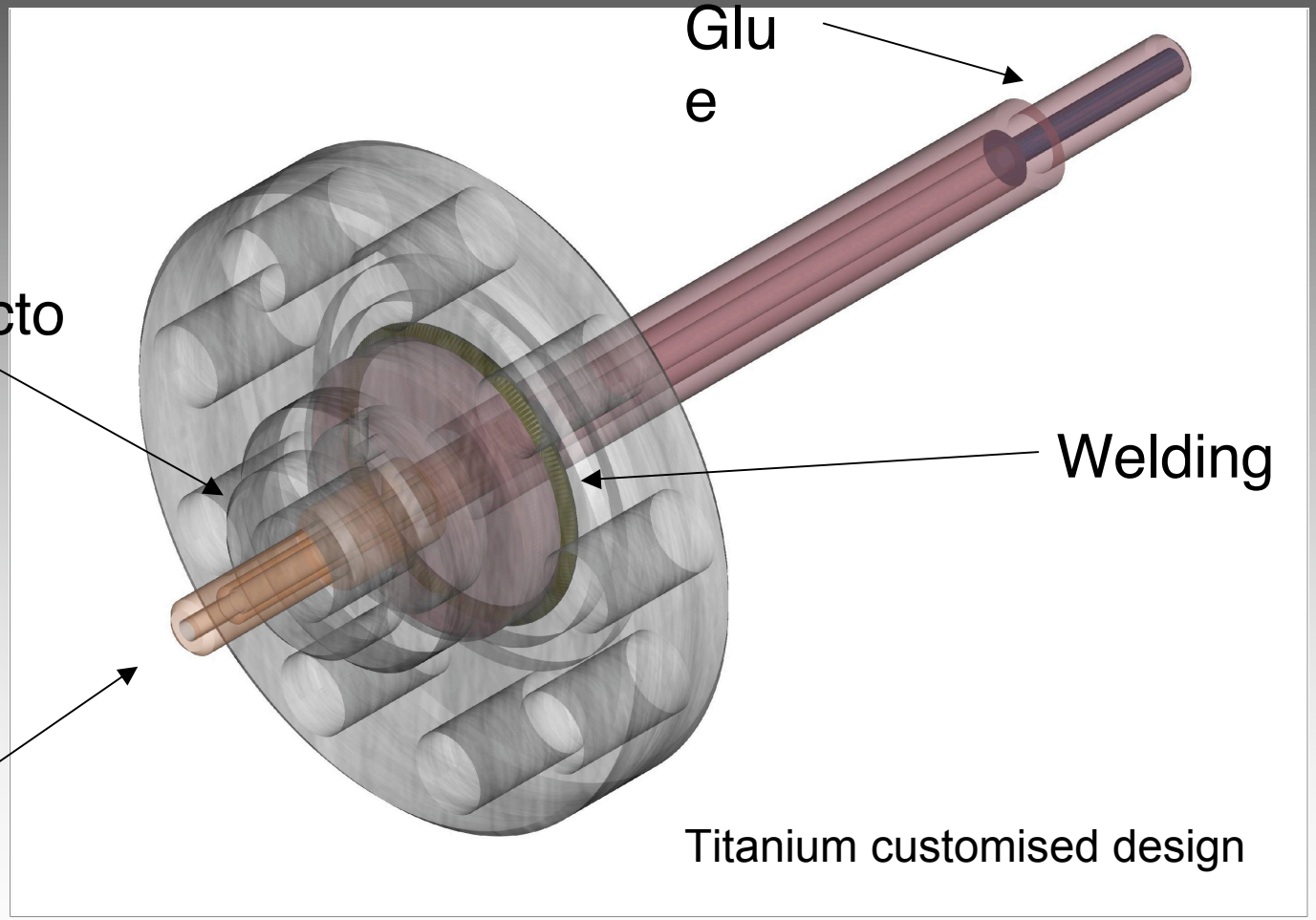
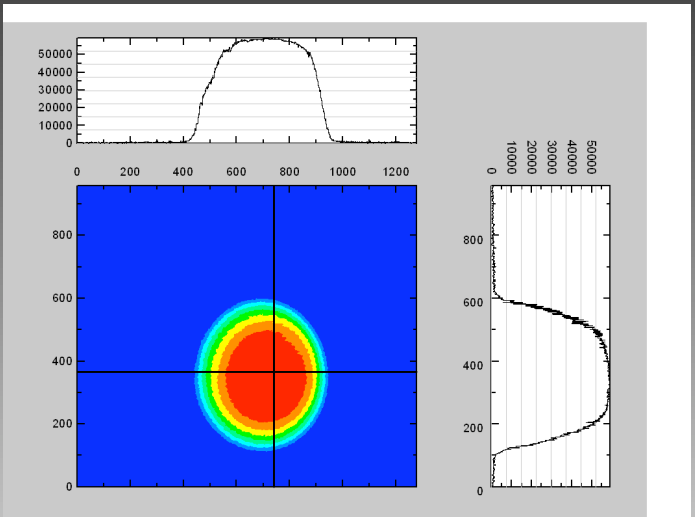
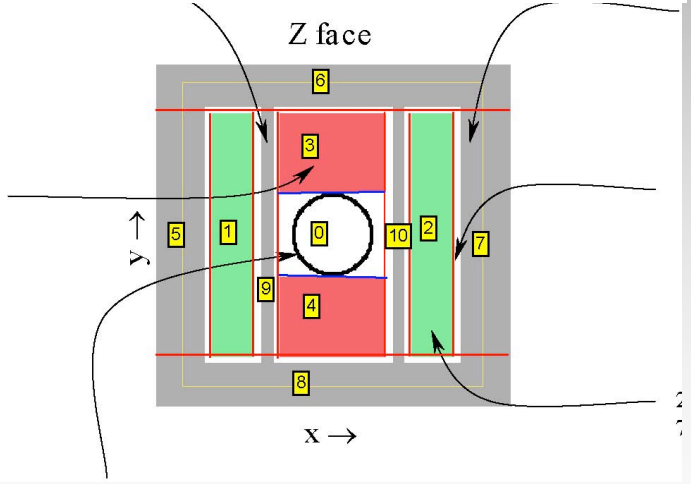
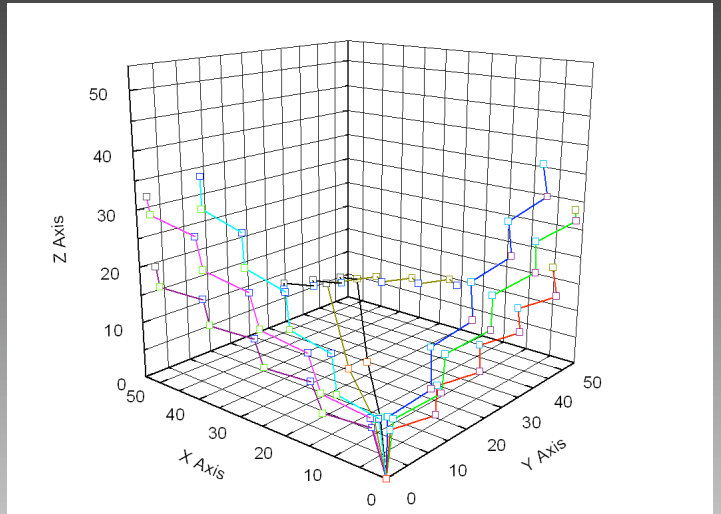
Inertial Sensor UV Kit (ISUK)

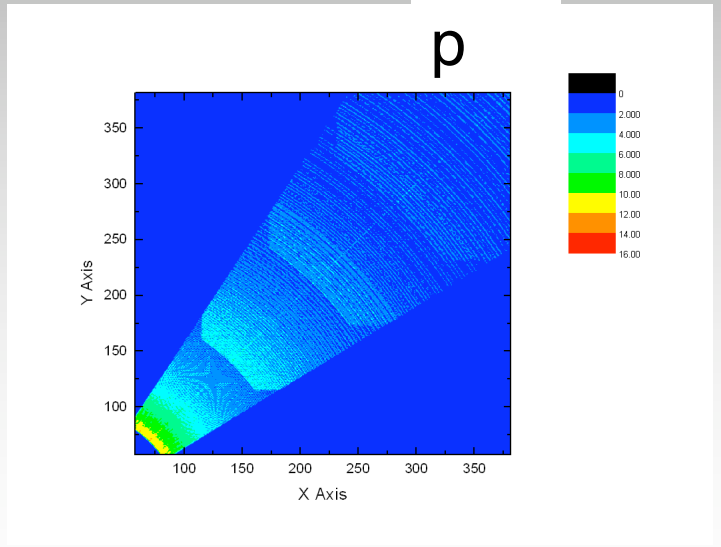


Light Distribution

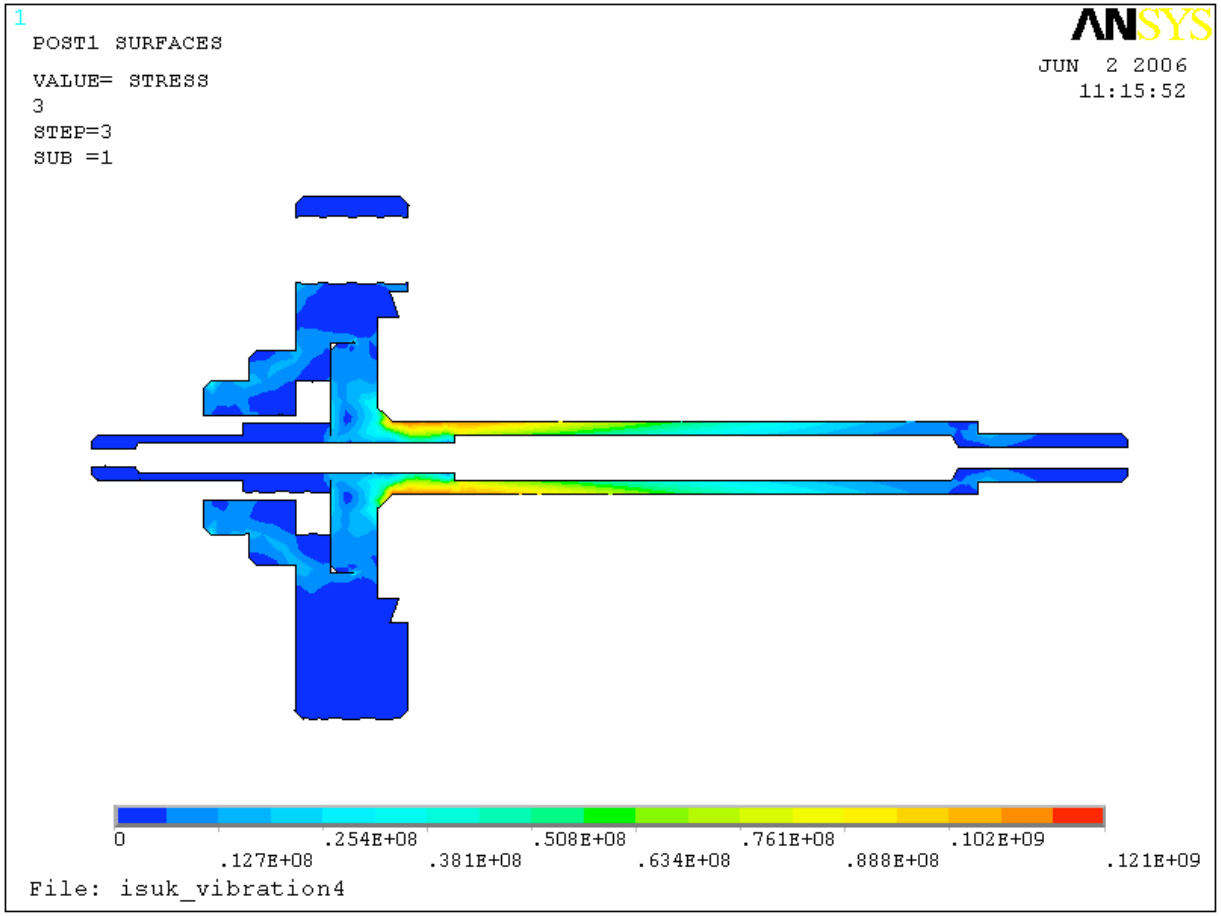




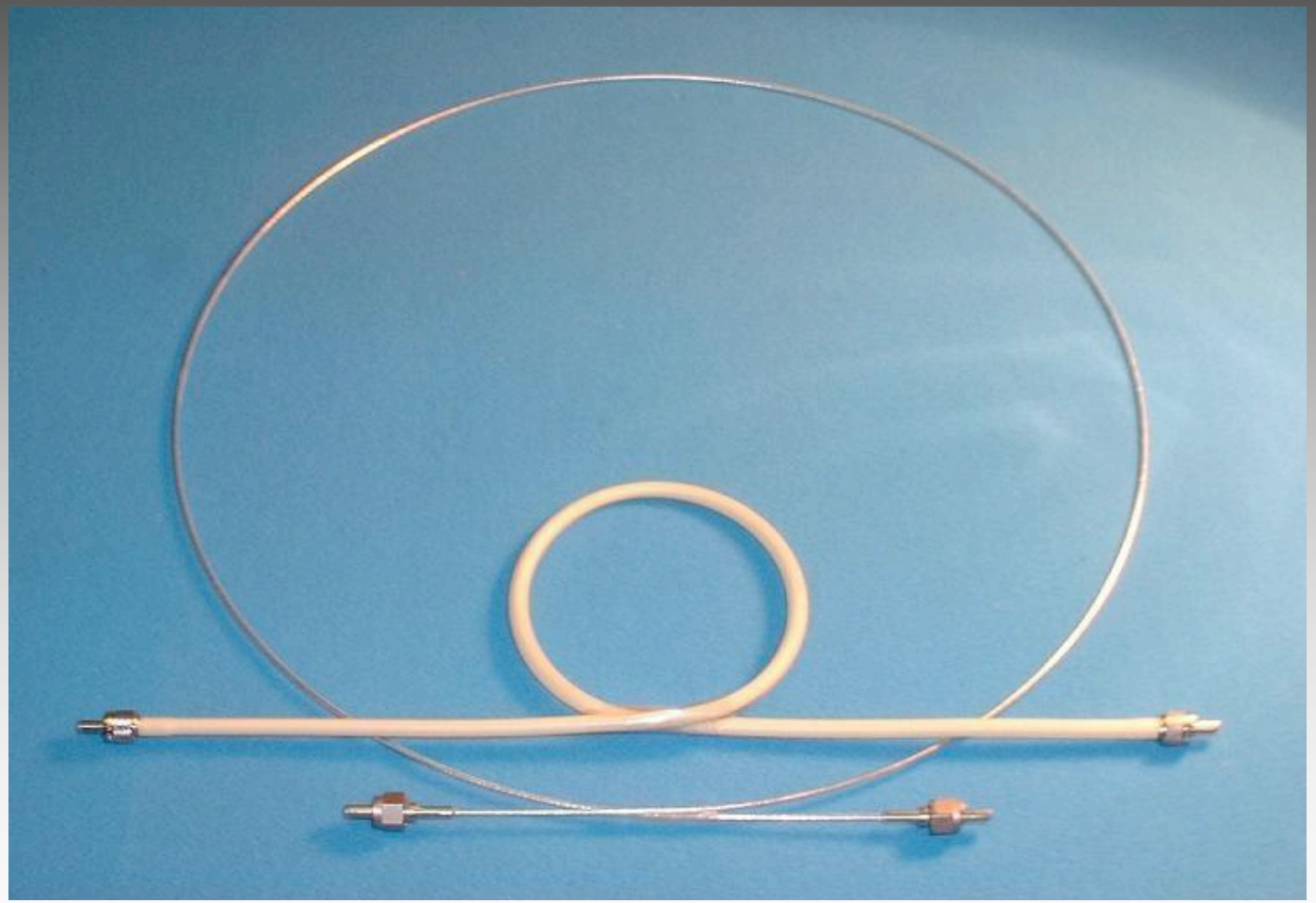




Structural Analysis



Fibre-Optical Harness (FOH)



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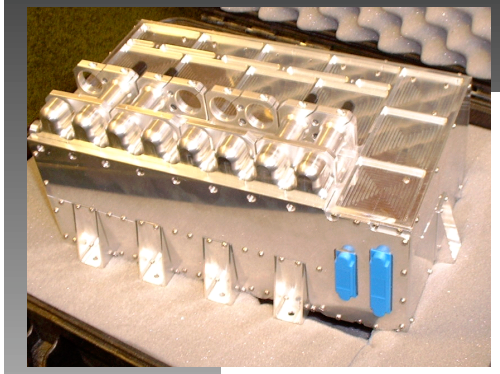
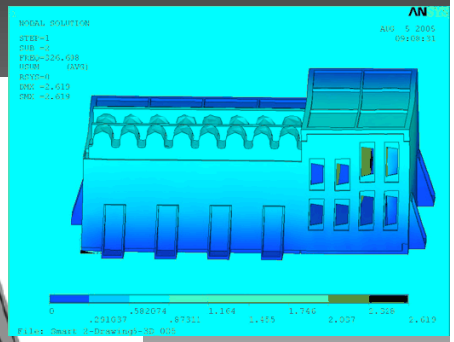
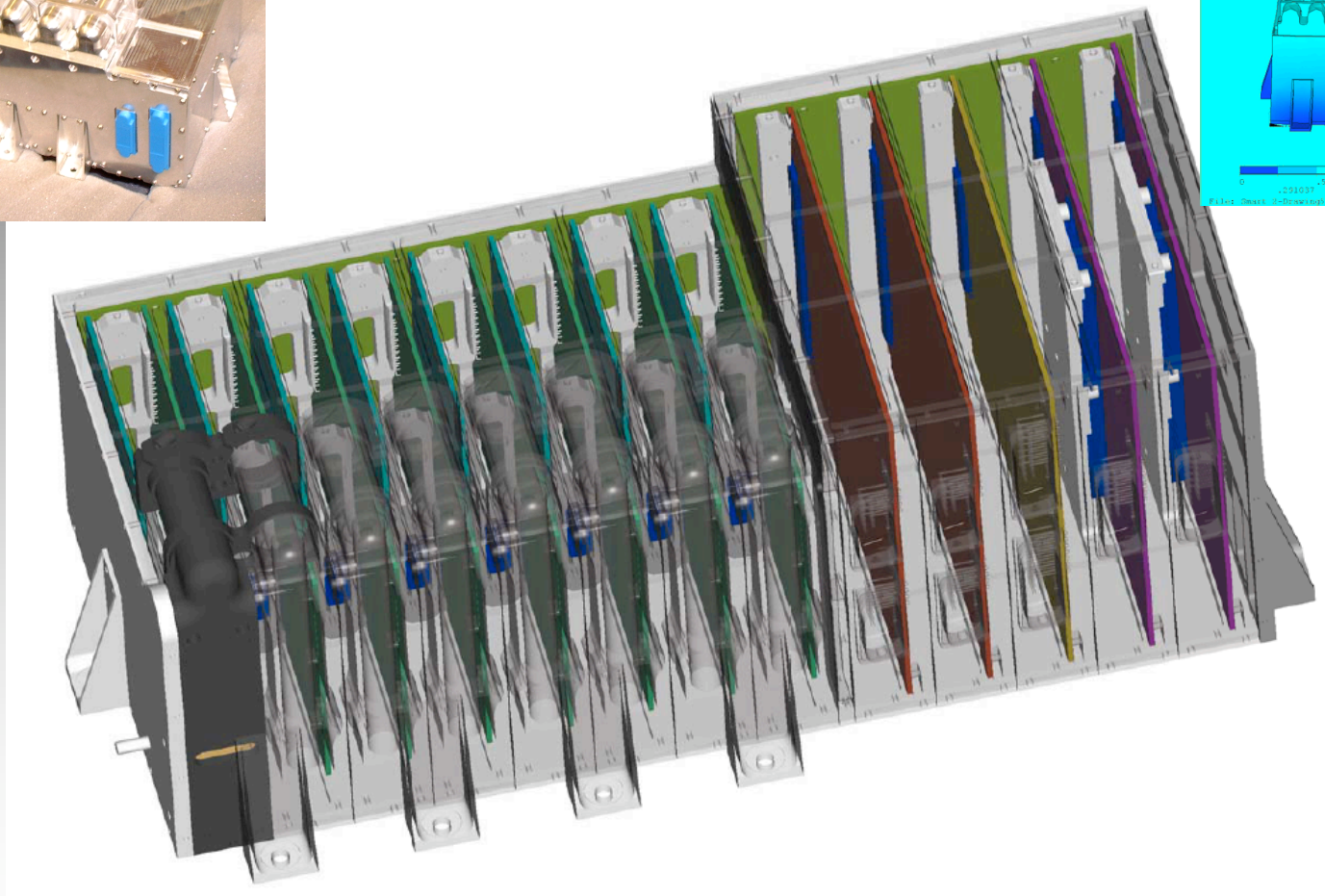
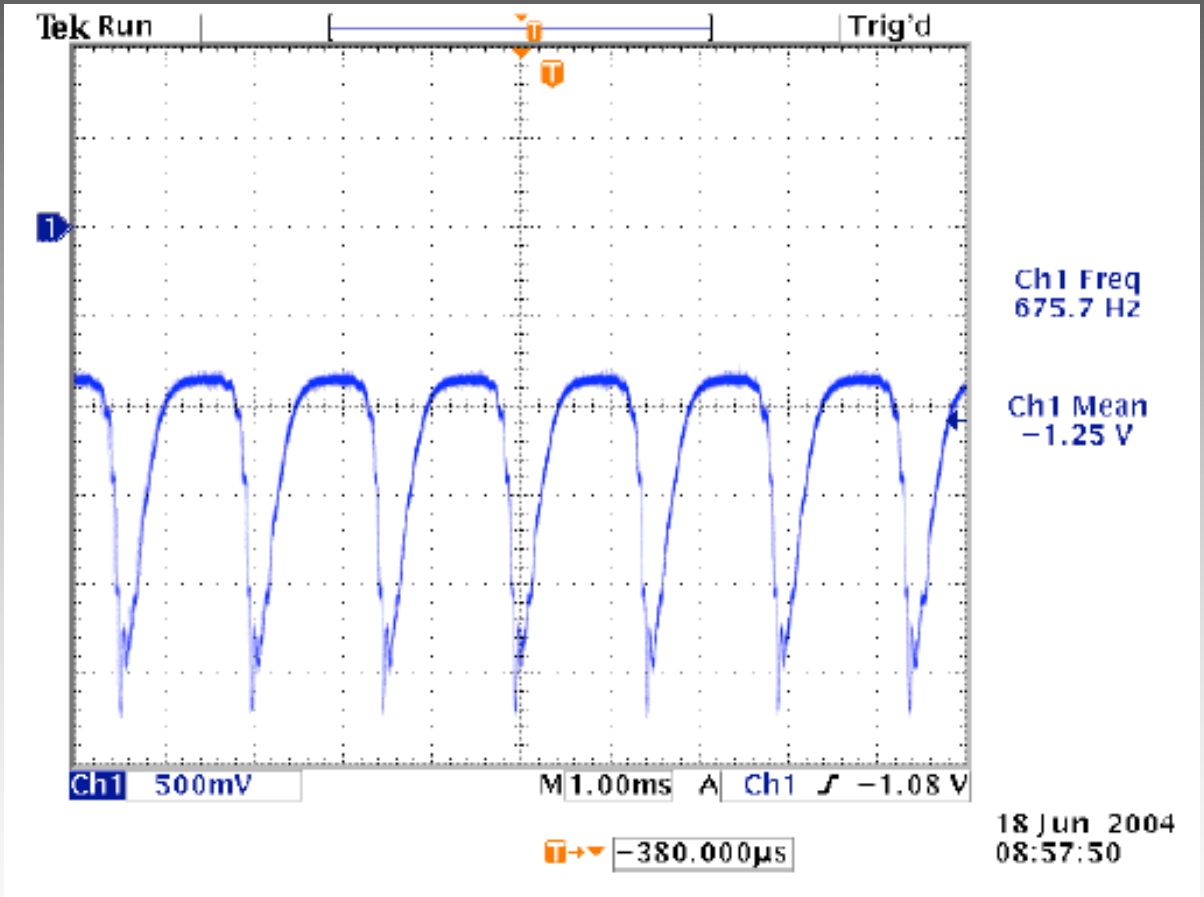
UV Lamp Unit (ULU)





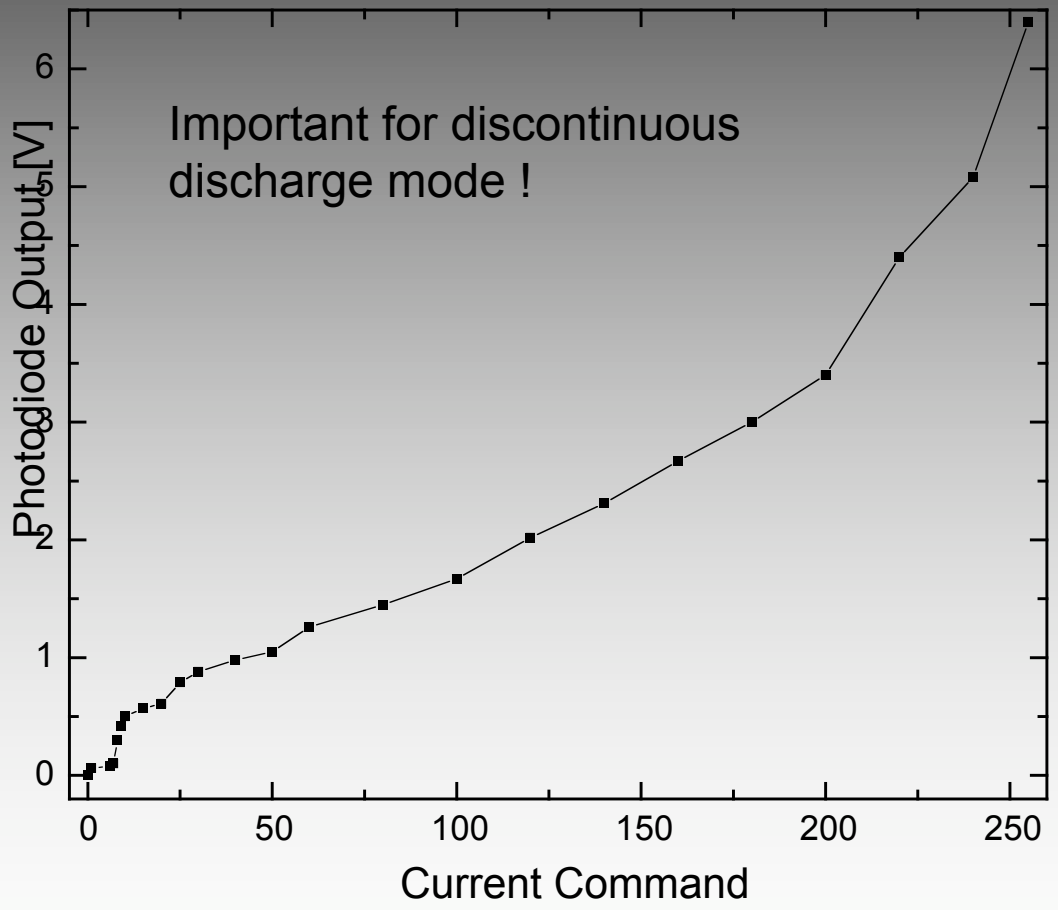


Pulse-width modulation

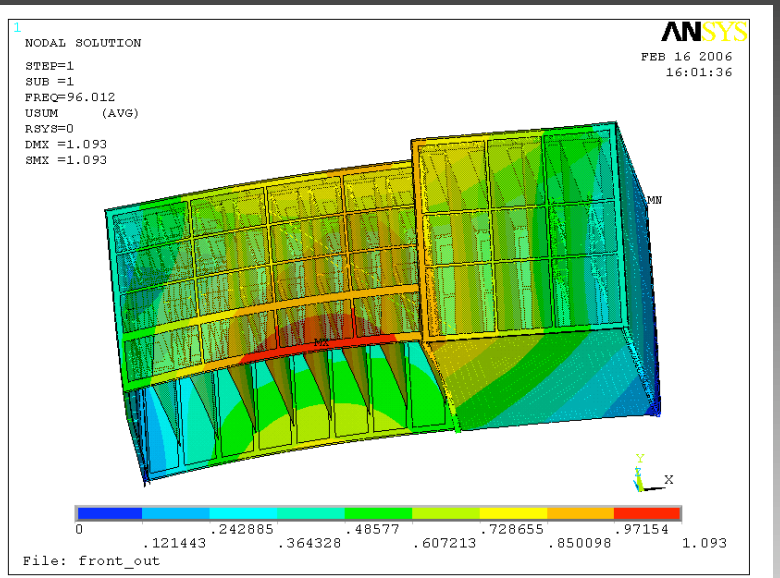


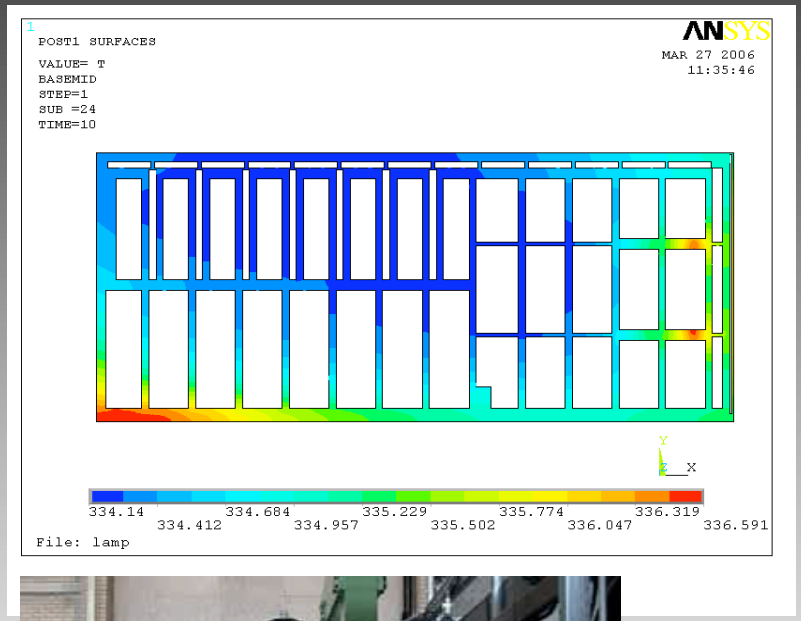
Dynamic Range

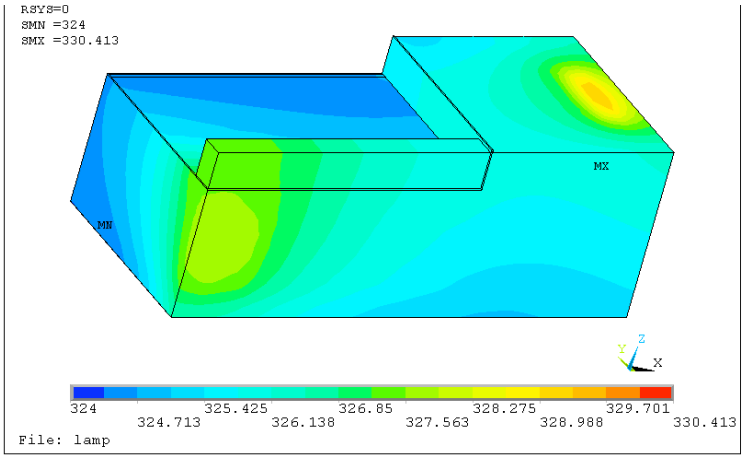
Dynamic Range ~ 140



Structural Analysis of ULU







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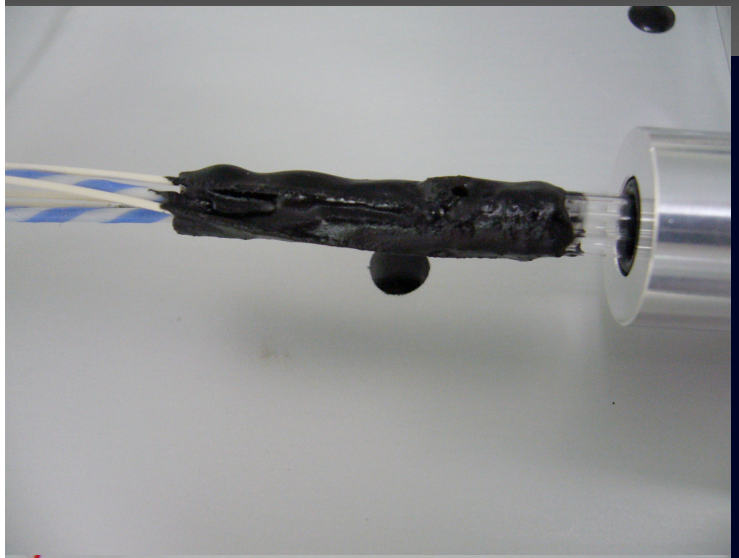
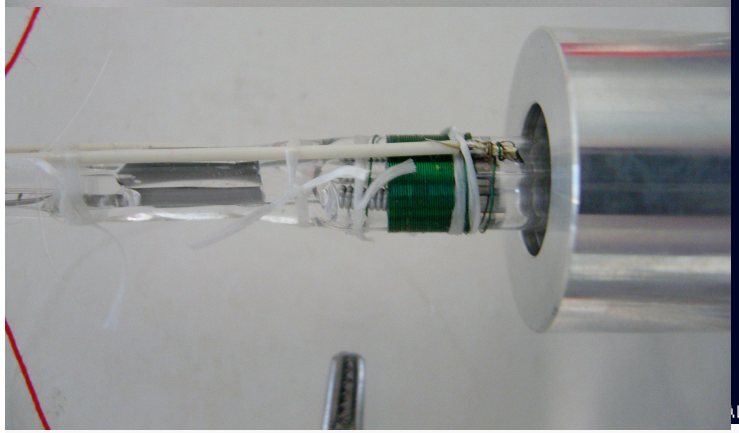
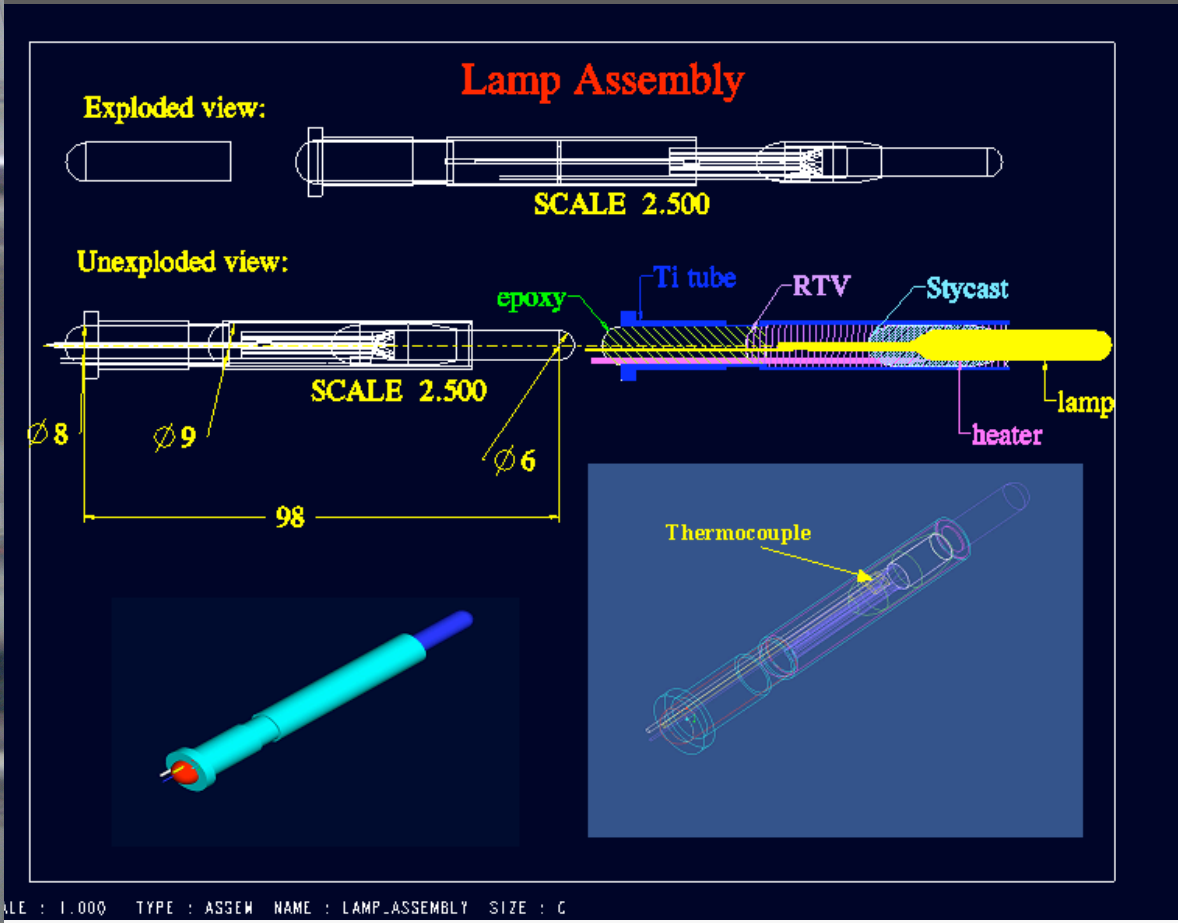
Lamp Manufacture







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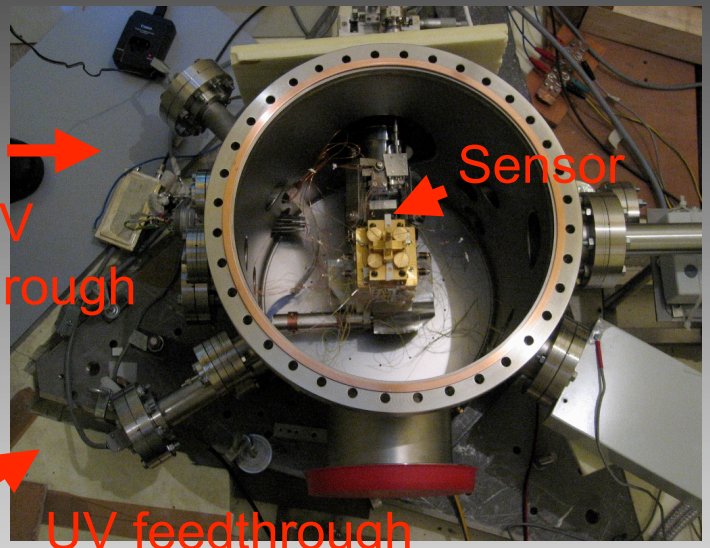
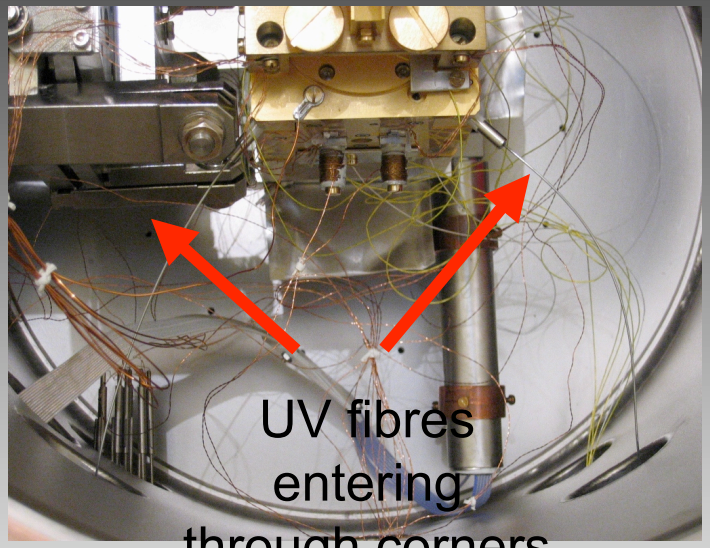
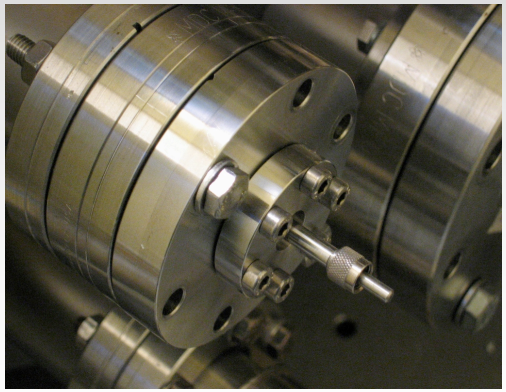
On Ground Testing at University of Trento

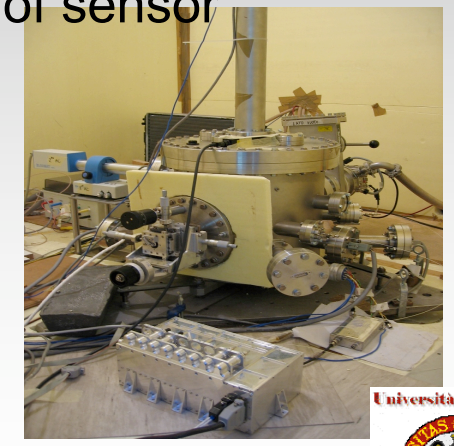




Close-up of a UV feedthrough:



The torsion pendulum and ULU:



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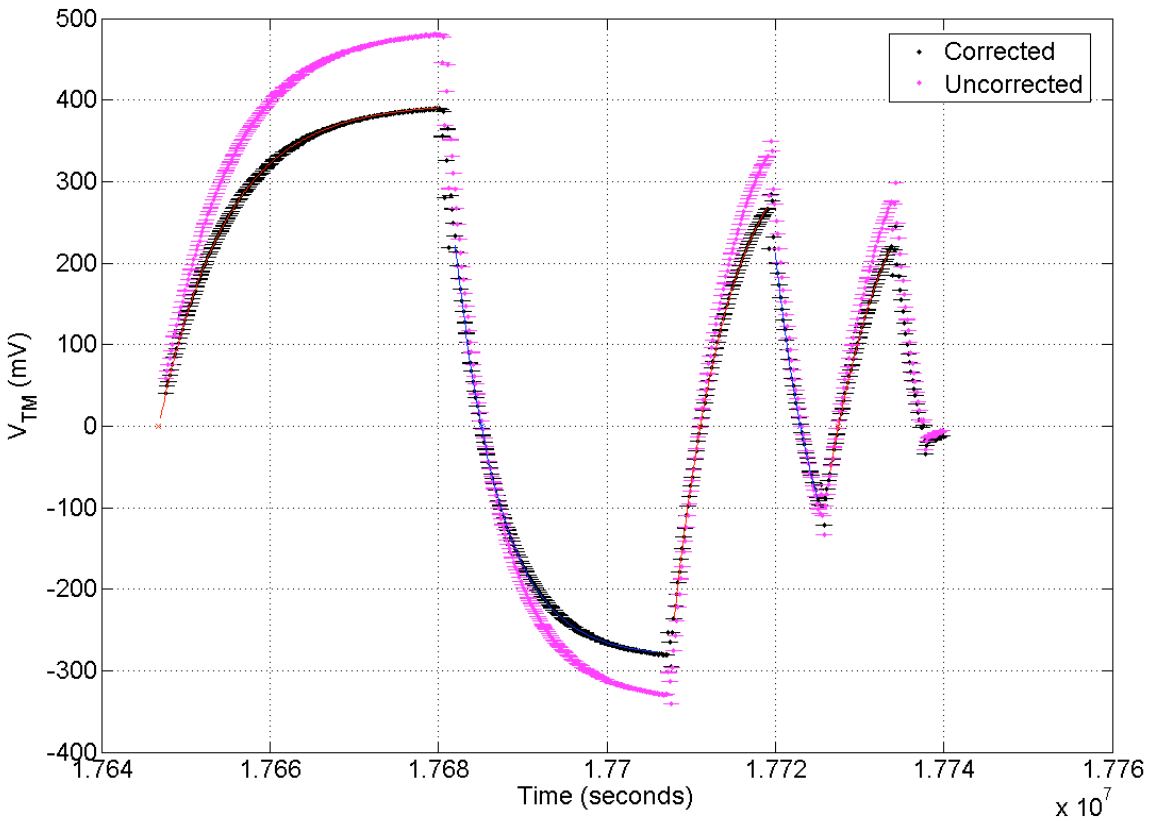
Test-Mass charging/discharging



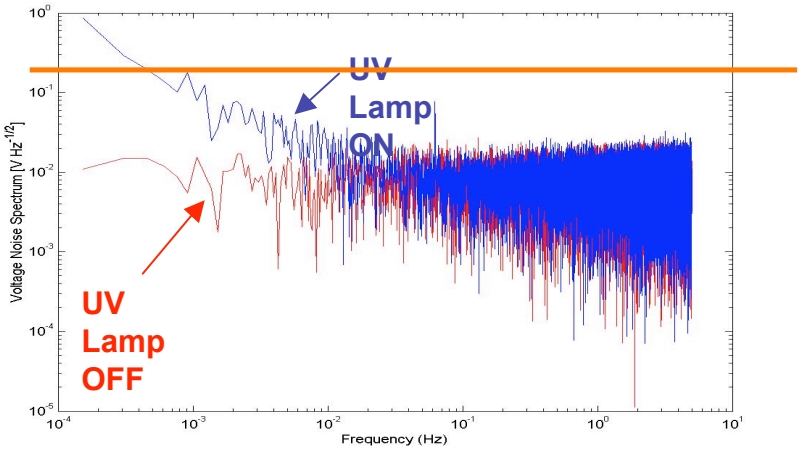
Charge rate measurements:
LAMP0 on TM / LAMP1 disconnected:

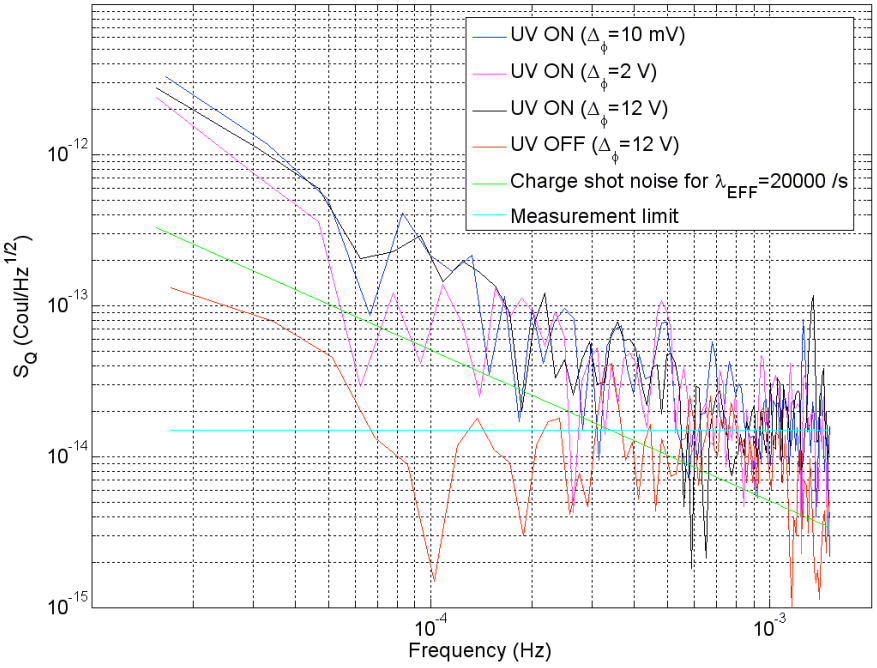
dQ/dt = 9875±15 e/s

LAMP0 disconnected / LAMP1 on electrodes:

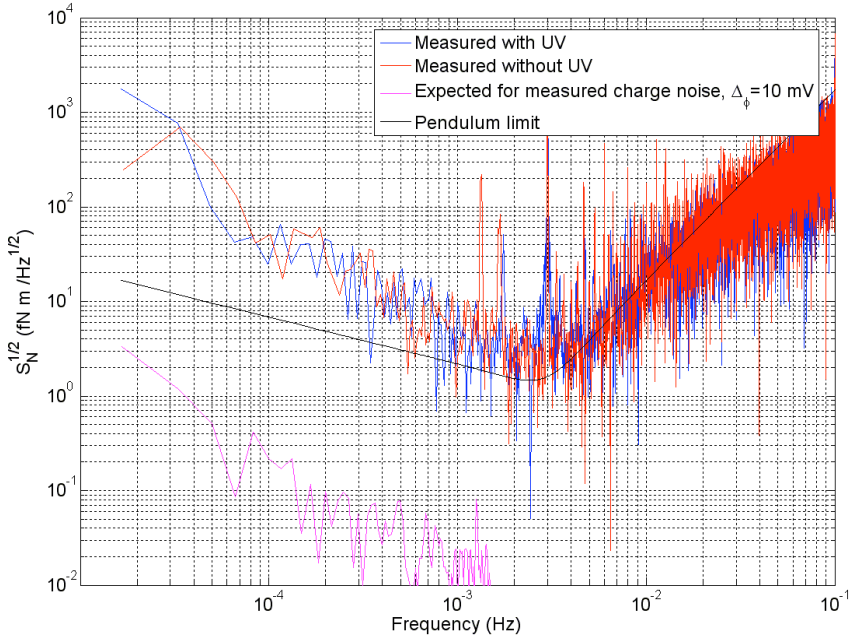
dQ/dt = -10050±25 e/s

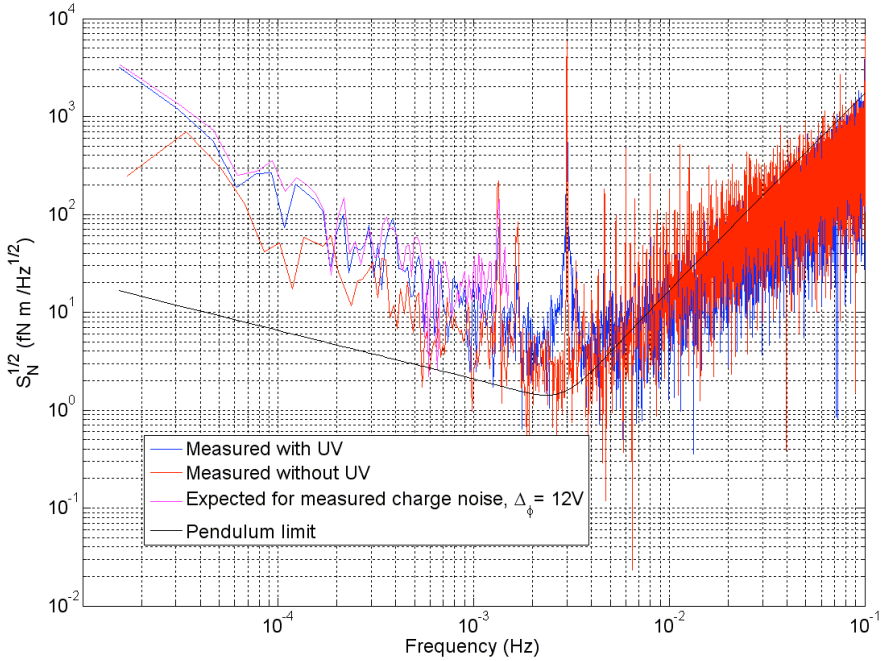
Lamp Output Noise - Charge Noise



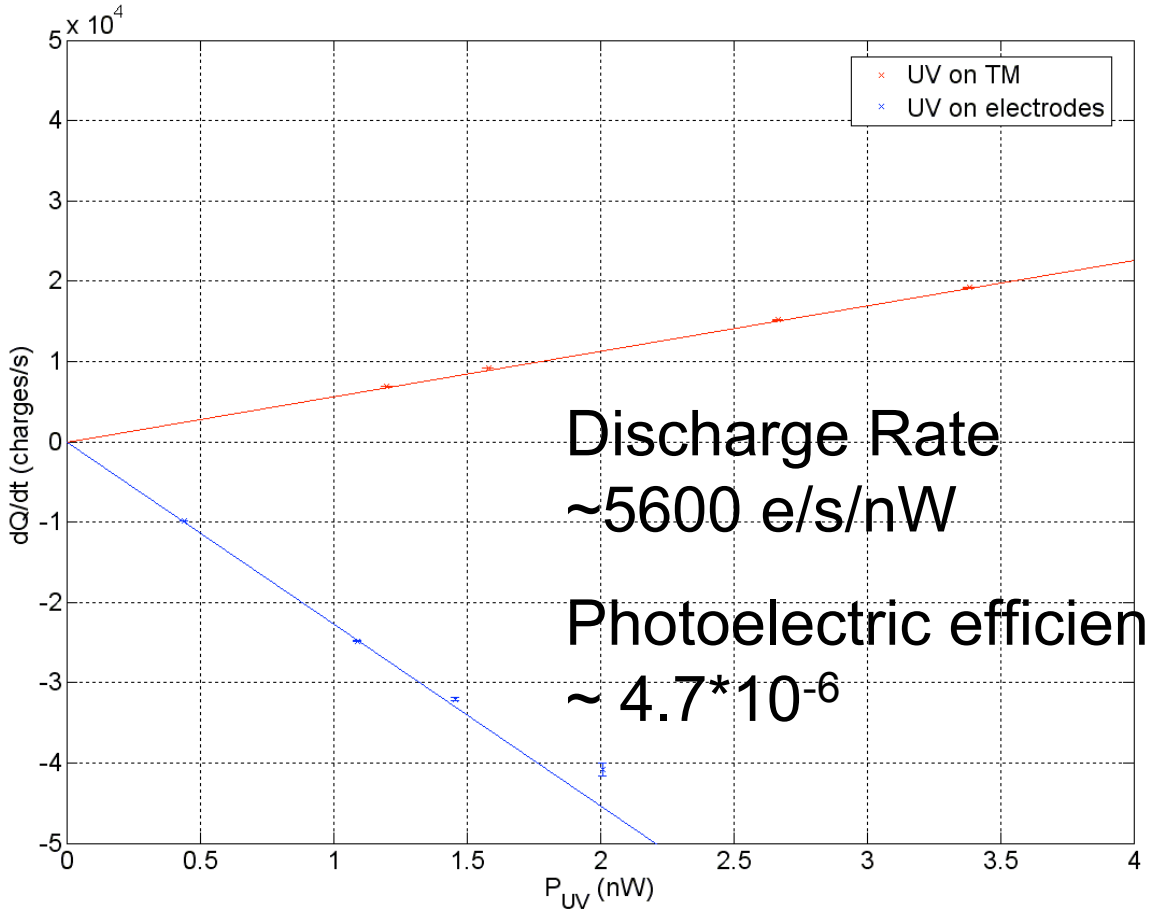


Pendulum torque noise





Discharge Rates



Discharge Rate
~5600 e/s/nW

Photoelectric efficiency
~ $4.7*10^{-6}$

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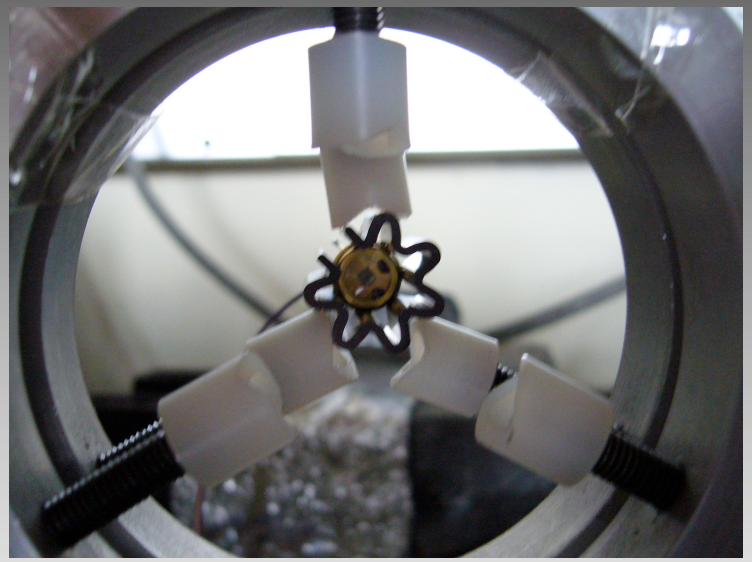
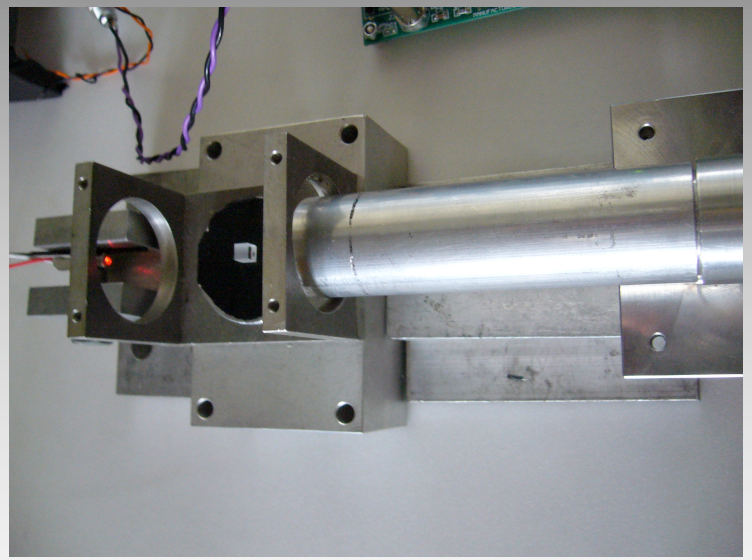
Current System

- Charge Management System is directly transferable to LISA
- Lamp Lifetime is sufficient with redundancy
- Continued research on possible improvements on power consumption, flexibility and second source technology

255 nm LED



635 nm to 212 nm THG



LED – Technical Issues

- Lifetime
  - Currently research grade devices from 3-4 suppliers – quoted only ~200 h CW at full power.
    Stanford University have achieved much longer lifetime when modulating (See Poster)
- Radiation Hardness
  - Needs to be tested, as GaN susceptible to doping by damage
- Flight engineering/qualification

Third harmonic generation

- Laser source at 635 nm
  - Very efficient source
  - Up to 5 mW output, 500 mW input, lower Power sources available
- Third harmonic: 212 nm UV
  - BBO Crystal ~ 10% (manufacturer's quote)
  - Measurements currently undertaken